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Review article

Effect of lumbopelvic myofascial force transmission on glenohumeral kinematics – A myo-fascia-biomechanical hypothesis

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ABSTRACT

Introduction: The clinical management of shoulder disorders do not commonly includes the myo-fascial–skeletal contributions from the lumbopelvic (LP) region. Nevertheless, a notable myofascial–biomechanical connection exists between LP and shoulder regions.
Aim: The current paper proposes a quantifiable medical hypothesis that there will be an increased anterior humeral head translation (ATHH) in the glenohumeral joint (GHJ) due to altered myofascial force transmission that results from LP dysfunction.
Material and methods: A literature search was conducted in Science Direct and PubMed databases for articles published from January 1990 to December 2015. Medical Subject Headings and other keywords for search were myofascial continuity, force transmission, muscle slings, lumbopelvic-glenohumeral joint and biomechanics.
Results and discussion: The hypothesis suggests a clinical reasoning that impaired myofascial force transmission from LP region as one of the contributing factors for shoulder pathogenesis. The hypothesis is proposed based on the anatomical and biomechanical relationship between the LP region and the contralateral GHJ. Evidences of myofascial continuity between the LP and GHJ, myofascial force transmission and integrated energy transfer theory are explained to strengthen the proposed hypothesis. An experimental method to test the proposed hypothesis is recommended for researchers and clinicians. A theoretical understanding of the pre stressed spring system via the myofascial chains is applied to strengthen the reasoning on the current hypothetical connection between LP and contralateral GHJ.
Conclusions: The implication of the new medical hypothesis may substantiate the understanding of the clinicians on the connections between the LP and the contralateral GHJ to consider a global myo-fascial–skeletal management of shoulder disorders.

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1. Introduction

Fascia is a dense irregular connective tissue that surrounds and connects every muscle forming a true myofascial continuity throughout our whole body.[1] The role of fascia in the musculoskeletal dynamics is crucial and gains attention in clinical practice.[2] In traditional clinical practice, the management of glenohumeral (GH) pathologies generally does not view the myo-fascial–skeletal contributions from the lumbopelvic (LP) region. The role of myofascial tissue that exists between the GH and LP region is rarely considered as one of the structures that contributes to the passive stability of GH joint (GHJ). In this paper, a biomechanical medical hypothesis which suggests an excessive anterior translation of the humeral head (ATHH) in GHJ is proposed which may be contributed by dysfunction of LP region. In normal clinical practice, the clinicians evaluate the stability of the GHJ through active and passive restraints. In current script, we postulate a hypothetical concept based on the myo-fascial–skeletal system by deriving empirical models and theories that may enhance a fresh understanding of the musculoskeletal control and stability of the GHJ. With excessive ATHH suggested to be one of the contributing factors for shoulder pathologies, the posed hypothesis on the myo-fascial–skeletal model provides clinicians a global and detailed clinical perspective toward the evaluation of GH disorders.

2. Aim

The purpose of this article is to present a myo-fascial–biomechanical hypothesis based on myofascial force transmission from global muscle connections between the pelvis and contralateral shoulder toward the regulation of the ATHH in GHJ.

3. Material and methods

3.1. *Data sources*

A literature search of published articles from January 1990 to December 2015 was conducted in the ScienceDirect and PubMed databases. The medical subject headings (MeSH) terminologies and other keywords for search were [(myofascial continuity) OR (myofascial lines) OR (anatomic continuity)] AND/OR [(force transmission) OR (myofascial force transmission) OR (transmission of forces in myofascial)] AND/OR [(anatomy train) OR (muscle slings) OR (myofascial slings) OR (oblique muscle chain)] AND/OR [(lumbopelvic) OR (sacroiliac) OR (hip-lumbopelvic complex)] AND/OR [(biomechanics) OR (biomechanical models) OR (biomechanical theories)]. The search strategy retrieved all articles in a conventional review manner.

3.2. *Article selection*

The articles were selected for the review if they had reported on the study search terminologies. First, the articles were included if the studies were presented on the myofascial force transmission. Secondly, the studies that presented on the muscle trains and anatomy of the myofascial slings were considered. Thirdly, any studies that presented a biomechanical model and theories were incorporated. Only those articles which were published in the English language were considered for the hypothetical review.

3.3. *Data extraction*

All the studies were examined for the reference lists to identify if any further literatures existed. Similarly, the titles and abstracts of all the identified studies were examined. A full article was identified when the literature was relevant to the study. The identified literatures were examined and used in the hypothetical review.

4. Results

4.1. *Theoretical framework and evidence*

4.1.1. *Anatomical relationship between the LP and contralateral shoulder joint*

The anatomical evidence between the LP and the contralateral GHJ exists through two integrated myofascial sling systems, namely posterior and anterior oblique sling, which serves as an anatomical connection between the LP region and contralateral GHJ.[3–5] The posterior oblique muscle sling that lies in the posterior aspect of the trunk involves muscles such as biceps femoris, gluteus maximus, thoracolumbar fascia, latissimus dorsi and upper trapezius. It runs from the LP region via the gluteus maximus spans up into the superficial and deep lamina of the posterior thoracolumbar fascia, crossing the mid body segment connecting up with latissimus dorsi and ending up in the contralateral GHJ. The anterior oblique sling which consists of hip adductors, transverse abdominis, internal and external oblique, the anterior fascia of the trunk and pectoralis major runs from hip-lumbopelvic region to contralateral GHJ.[3–5] Fig. 1 indicates the anatomical relationship between the LP region and contralateral GHJ. The transfer of forces across anterior and posterior oblique sling muscles may assist to maintain the tensegrity of the GHJ.[3] On the other hand, any impairment of the two muscle slings may result in alteration of the accessory movement pattern and joint kinematics of GHJ.[6]

4.1.2. *Biomechanical relationship between LP and contralateral shoulder joint*

Human walking involves specific coordination patterns between upper and lower body segments.[7] Pelvic angular momentum is counterbalanced, either directly by counter-rotating the thorax or indirectly by swinging an arm.[8] During human locomotion, there is a reciprocal movement of upper extremity and lower extremity and it is cross-patterned, with alternating arm swing and leg movement to achieve biomechanical efficiency.[9,10] Pelvic rotates from right to left around a vertical axis and two innominate bones alternately rotates forward and backward synchronously with activation of gluteaus maximus, while the shoulder girdle rotating in the

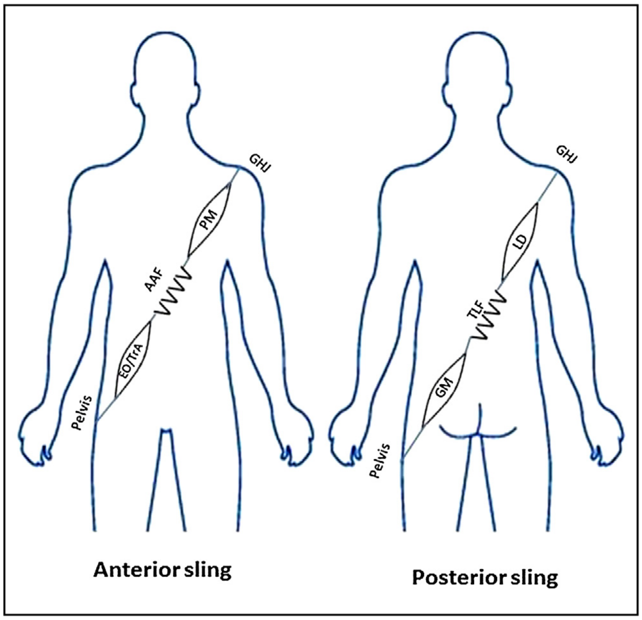

Fig. 1 – Anatomical relationship between the LP region and contralateral shoulder joint through the posterior thoracolumbar fascia link. EO – external oblique, TrA – transversus abdominis, AAF – anterior abdominal fascia, PM – pectoralis major, GM – gluteus maximus, TLF – thoracolumbar fascia, LD – latissimus dorsi, GHJ – glenohumeral joint

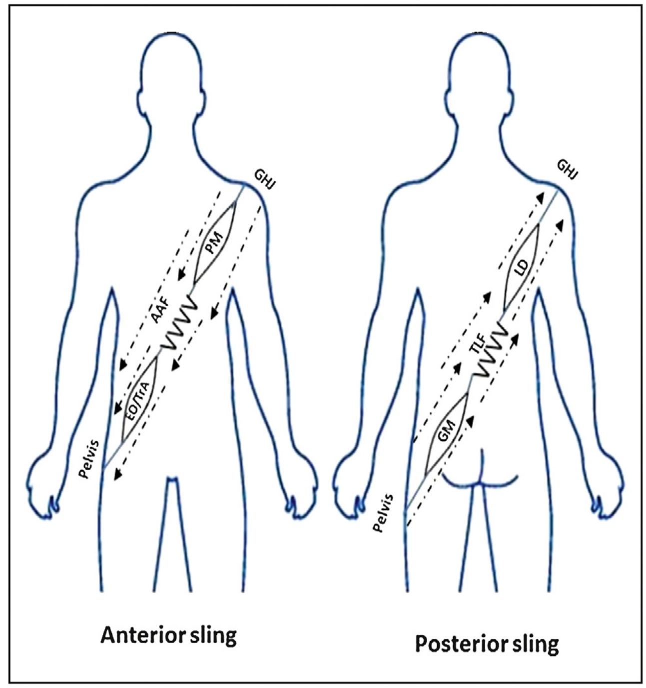

Fig. 2 – The direction of myofascia force transmission from LP region toward contra lateral GHJ. Direction of the dotted line indicates the direction of the myofascial force moment.

opposite direction during walking.[9,11,12] At the same time, the trunk will counter-rotate and contralateral latissimus dorsi muscle is activated during counter-rotation of the trunk.[10] Thus, in addition to an anatomical connectivity between gluteus maximus and latissimus dorsi, the engagement of gluteus maximus and latissimus dorsi in the posterior oblique chain during locomotive action further postulates the kinetic relationship between LP and GH region.

4.1.3. *Myofascial force transmission*

The mechanism of myofascial force transmission that occurs between gluteus maximus, thoracolumbar fascia and lattisimus dorsi may assist to explain the relationship between LP region to the contralateral GHJ. Myofascial force transmission refers to transmission of muscular force through the continuous endomysial fascia stroma within the agonistic muscle as well as with the adjacent antagonistic and synergist muscles.[13,14] Myofascial force transmission occurs via three pathways namely intramuscular, intermuscular and epimuscular force transmission. Thus, a force generated at any one joint is transmitted through endomysial–perimysial network of myofibrils directing the force generated proximally in one muscle to a distance muscle at one segment and as well as several other intersegments in another part of the body.[14] Such extra muscularly transmitted force targets joint capsules, ligaments and other muscles within the same or other compartments and ultimately the joints.[14] Fig. 2 explains the myofascial connection and force transmission between LP dysfunction and contralateral GHJ. Thus in current hypothesis, any altered myofascial force in case of LP problems may get transmitted across the LP-GHJ regions through intra-inter muscular force transmission between segments and different regions of the body.

4.1.4. *The prestressed two spring model*

As per the prestressed two spring model, any increased or decreased tension in one of the spring may cause the opposite spring system to overact which may affect the net force moment and neutral zone of the joint structure.[15] In our body, the force generated by the myofascial continuity of the posterior oblique sling and anterior oblique sling may be modeled as two non-linear elastic spring like cables. Both these elastic cables connect and intersect at the shoulder joint after having originated from the LP region. It may be postulated that the neutral position of the humeral head (HH) in GHJ is maintained as long as the net passive force moment generated by both of these myofascial cables equals to zero (Fig. 3). When the contractile force generated by the muscles of posterior oblique sling muscles is impaired as it may happen in LP dysfunctions, then the force generation of the anterior myofascial sling may increase the net moment toward one side of the elastic cable system. It may be possible that the altered myofascial force gets transmitted intra- and intermuscularly to various structures such as the muscle, soft tissues such as capsule, ligament and eventually may affect the passive stability of the GHJ. Thus the current medical hypothesis postulates that any such increase of net force moment in the anterior elastic cable system may contribute to ATHH in GHJ affecting the shoulder joint kinematics.

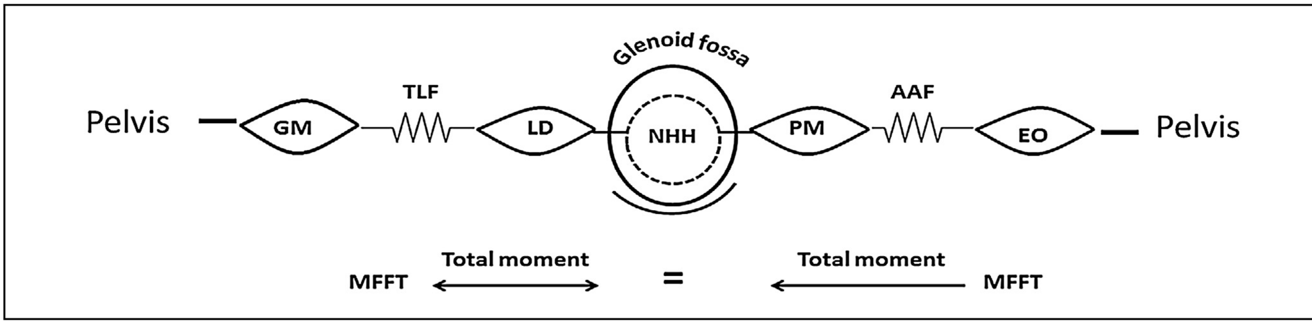

Fig. 3 – Pre-stressed spring model between posterior and anterior muscular chain between LP and shoulder region.

4.1.5. *Integrated system and energy transfer theory*

The integrated energy transfer theory postulates the capability of the myofascia to influence the movement patterns and joint kinematics by the release of kinetic energy. The myofascia remains as a source of dynamic energy storage during walking.[16] The contraction of the myofascia such as the anterior and posterior oblique myofascial slings during functional movement, such as walking transmits energy as an integrated unit between upper body and lower body through spine similar to bow-string mechanism.[17–19]

The contraction of the muscles and the associated fascial system acts like an elastic spring by shortening and lengthening with release of energy that acts on the joints and movements. In the above said context, the posterior and anterior oblique sling system may act as an energy regulating string connected to LP and GHJ region. Recent knowledge about the facial contractility and the presence of fibroblasts in fascia supports that the myofascial system can influence the musculoskeletal dynamics and muscle tone.[20] Based on the above said principles, any dysfunction of LP region may likely cause impaired myofascial force and energy transmission across slings, which may influence the position of the HH in the GHJ.

4.2. *Hypothesis*

This article constructs a theory based on myo-fascial–skeletal biomechanical model whereby the myofascial force contributions from the muscles, that connects the LP region and GH has an effect on the humeral position in the GHJ. The hypothesis proposes that the altered myofascial force transmission from both the anterior and posterior oblique sling muscles due to LP dysfunction contributes to the excessive ATHH in the contralateral GHJ.

The hypothesis suggests that any dysfunction of LP region may contribute to contralateral shoulder disorders through the altered myofascial force transmission from the posterior oblique chain muscles. Hence, clinicians may consider evaluating and normalizing the myofascial force transmission from the LP region, particularly from gluteus maximus and latissimus dorsi myofascial connection as part of the management of shoulder disorders.

4.3. *Evaluation of the hypothesis*

The myofascial medical hypothesis can be measured by examining the kinematics of the shoulder joint and as well as by measuring the kinetic changes of the posterior oblique muscle system. The hypothesis about the excessive ATHH in GHJ can be quantified by examining the proper alignment of humerus within the glenoid fossa, using real-time ultrasonography imaging and by quantifying the amount of ATHH within the glenoid fossa. An understanding of the amount of ATHH during an applied stress provides clinician information regarding the direction and magnitude of the anterior laxity at GHJ. Secondly, if ATHH results due to impaired myofascial force transmission in posterior oblique sling, then the muscle activation of the posterior sling muscles such as biceps femoris, gluteus maximus, latissimus dorsi may also be demonstrated.

In practice, such activation of posterior sling muscles can be investigated through surface electromyography. Thus the evaluation of the hypothesis is possible for researchers and clinicians through well controlled study design which may highlight the role of myofascial contribution from LP to contralateral shoulder region.

5. Discussion

Evaluation of the myofascial force contribution from LP region is seldom considered in clinical practice of shoulder management. As ATHH in the glenoid fossa that results in impaired joint kinematics is one of the causes of shoulder problems, evaluating the ATHH in GHJ in the context of LP dysfunction may be meaningful for clinicians.[21]

In this paper, the anatomical, functional and biomechanical links between the LP region and GHJ were explained for the understanding of the readers to support a myo-fascial–skeletal medical hypothesis. With research on fascial anatomy receiving attention, more biomechanical studies related to motor control and movement dysfunctions which highlight myofascial system is warranted. In this context, the current hypothetical paper highlights the need to consider the examination of the LP region for GHJ disorders and propose a myo-fascial–skeletal model for musculoskeletal dysfunctions of GHJ in clinical practice.

The myo-fascial–skeletal hypothesis proposed in this article may be catalytic for further scientific research and new therapeutic directions for clinicians and researchers to understand the myo-fascial–biomechanical connection between LP and GH regions.

5.1. *Interaction of lumbopelvic-shoulder myofascial complex*

Recent emerging scientific evidences have started to highlight the myo-fascial–biomechanical interactions between LP and GHJ.[22,23] An in vivo study provided empirical evidence that myofascial force transmission occurred from latissimus dorsi to contralateral gluteus maximus.[22] Evidence of myofascial force was documented when manipulation of the latissimus dorsi tension influenced passive tension of the contra lateral gluteus maximus that resulted in shifting of the resting position of the contralateral hip joint.[22] Further evidence on the interaction between the LP and GHJ was postulated among patients with sacroiliac joint dysfunction where altered myofascial force transmission from LP region resulted in an altered HH position in the contralateral GHJ due to altered myofascial force transmission across oblique sling muscles in event of LP region dysfunction.[23,24] The current script propose a hypothesis that the reduced force transmission in posterior sling myofascial system might be overpowered by the anterior myofascial force generated in the anterior sling system which may cause the ATHH (Fig. 4). With only very few limited evidences available on the topic,[22,23] there is a paucity in high quality scientific evidence in the myofascial–biomechanical interactions between LP and GHJ. Thus, there is a real need to validate the current hypothesis before further implementation of the hypothesis into the clinical practice.

5.2. *Kinetic chain model*

The kinetic chain model may provide further support for the myofascial connection between LP and GH regions. The kinetic chain model is a biomechanical model that depicts body as a kinetically linked chain from proximal to distal joint segments which works together to produce a desired function.[25] The action of throwing may be considered as a good example to illustrate the kinetic link between the pelvis-hip-trunk segments to the contralateral shoulder segment.[26] Interestingly, the proposed myo-fascial–biomechanical hypothesis is in favor with the kinetic link between LP and GH regions. According to the kinetic chain concept, the practitioners are suggested to consider the kinetic link and motor activation pattern of leg and trunk segments during rehabilitation of shoulder segments. In this case, the muscles of the proximal

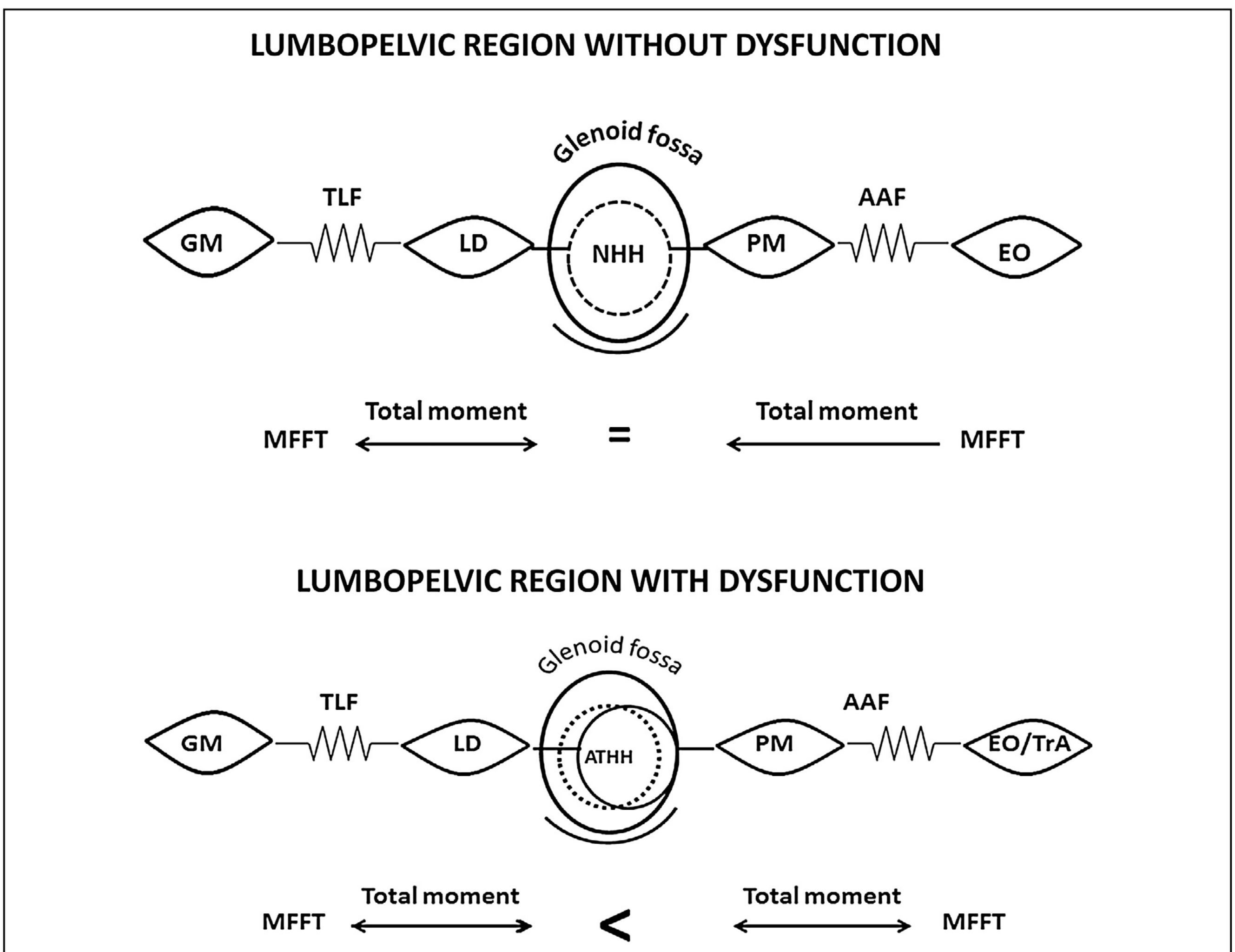

Fig. 4 – Altered force in the pre-stressed spring model resulting in ATHH caused by increased moment in anterior muscular chain.

segments such as hip and trunk facilitate the entire kinetic system that transforms the momentum to the distal segment at shoulder joint that completes the segmental interaction.[24,26] Any physical conditions that alters the kinetic chain, particularly on the core such as trunk, back and proximal part of the lower limbs was suggested to alter the distal segments leading to a shoulder dysfunction.[26] Therefore, the effective functioning of the shoulder joint is determined by the larger muscles of hip and trunk which was suggested to position the thoracic spine that improves stability of shoulder. Thus, the kinetic chain model supports the hypothesis that any dysfunction of the LP region might result in shoulder dysfunction and alter force variation at the shoulder joint.

5.3. *Clinical application*

The current proposed medical hypothesis invite clinicians to consider musculoskeletal dynamics as a holistic unit formed by myofascial continuity and force transmission that postulate examination of the LP region in the event of shoulder disorders. The current hypothetical model might influence the diagnosis and treatment of the musculoskeletal disorders LP region and shoulder.[27] Absence of high quantity-quality studies and lack of clinical validation among patients are some of the limitations for the proposed medical hypothesis. In general, clinicians do not consider looking into the LP region and related myofascial force transmission as contributing factors for shoulder pathogenesis. Nevertheless, the proposed testable medical hypothesis may explain the reasoning on why some of the patients with shoulder pain may progress to develop chronic shoulder pain or recurrent shoulder pain especially when a holistic approach was not considered. In such context, the myofascial continuity and myofascial force transmission between the LP region and shoulder may be one of the missing links in the management of shoulder disorders. In practice, an understanding of the myofascial force transmission from the LP region and its effect on GHJ may aid practitioners' knowledge on the rehabilitation management of shoulder problems.

6. Conclusion

The existing evidence supports myo-fascial–biomechanical connection between LP region and contralateral GHJ. However, very few studies have explored the myofascial link between LP and GH regions with a paucity of knowledge exists on the topic. Therefore, well designed scientific studies that put myofascial force transmission and motor pattern control to explore the myo-fascial–skeletal system linking hip–sacroiliac–lumbar–thorax–shoulder sequence are recommended.

Conflict of interest

None declared.

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